In the animals of group B (Table IV) where only the Ruben valve was used, the difference between the means of the half-clearance times for animals resuscitated by 5% and by 7% carbogen again no longer exists—13.8 and 13.4 minutes.

TABLE III.—Half-clearance Times from Three Dogs when Resuscitated with 5% Carbogen and Then with 7%, Using a Heidbrink Valve and Then a Ruben Valve in the Circuit

Dog	Heidbrink Valve		Ruben Valve	
	5% Carbogen T 2 (min.)	7% Carbogen T 2 (min.)	5% Carbogen T 2 (min.)	7% Carbogen T 2 (min.)
4	21	18.5	10	8
5	19	19	15	12
8	27	15.5	17	24
Mean	22.3	17.7	14	14.7

TABLE IV.—Half-clearance Times of 10 Dogs Resuscitated with 5% and 7% Carbogen with the Ruben Non-return Valve in the Circuit

Dog	5% Carbogen. T 2 (min.)	7% Carbogen. T 2 (min.)
A	9	9
B	17	12.5
C	10	15
D	10	12
E	15	15
F	11	6
G	16	15
H	13	14.5
I	21.5	19
J	15	16
Mean	13.75 (S.D. 3.9)	13.40 (S.D. 3.7)

Discussion

Although the results of the first series of experiments (Table II) demonstrate that 7% carbogen clears the blood of carbon monoxide more rapidly than does 5% on the same animals, the second series (Tables III and IV) shows no such difference. The only alteration in the technique of resuscitation is the use of the Heidbrink valve for the first group and the Ruben valve for the second. Further, the difference in mean half-clearance time shown in Table II when 5% and 7% carbogen are used with the Heidbrink valve disappears when the Ruben valve is used. This clearly demonstrates that the difference is a function of the respiratory valve used in the circuit and indicates the importance of using a respiratory valve which does not permit rebreathing when resuscitation is undertaken.

There seems to be little point in using 7% carbogen in preference to 5%, since 5% carbogen will clear the blood of monoxide as efficiently as 7% if a respiratory valve which does not allow rebreathing is placed in the circuit by which the mixture is applied.

None of the dogs in either series died during gassing or resuscitation, though many were gassed to apnoea—an event which occurs shortly after the 70% level of carboxyhaemoglobin is recorded by the reversion spectroscop. Respiratory failure always occurred before cardiac arrest. When respiration ceased, artificial respiration was undertaken by rhythmically squeezing the rebreathing bag filled with the appropriate carbogen mixture for the experiment. All the dogs recovered uneventfully and seemed perfectly well by the following day. Up to three months later there was no evidence of neurological or other damage.

Summary

Two groups of 10 dogs were gassed with carbon monoxide until the level of carboxyhaemoglobin was 70%. The animals were then resuscitated using 5%

and 7% carbogen in turn. In group A a Heidbrink valve was placed in the resuscitating circuit and there was a difference in efficiency of resuscitation in favour of 7% carbogen. In group B a Ruben non-return valve was placed in the resuscitating circuit and no difference between the efficiency of 5% and 7% carbogen was demonstrated. The choice of a respiratory valve which prevents rebreathing when resuscitation is undertaken in carbon monoxide poisoning is thus more important than the choice of a 5% or a 7% carbogen mixture.

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A NEW STERNAL REFLEX IN CASES OF SEVERE CEREBRAL DAMAGE

BY

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In man the sternal region has a specific sensitivity that can be explained in terms of ontogenetic and phylogenetic evolution. Sherrington (1898, 1911, 1915) observed that stimulation of the sternal area in male frogs evokes reflex movements of the fore-limbs, and that these movements are enhanced by decapitation. This, then, is purely a spinal phenomenon suppressed by higher levels of the central nervous system. Many physiological reflexes are suppressed as cerebral evolution progresses, especially if they have no significant value in normal states. But these reflexes become evident in pathological conditions. Minkowski (1921, 1928) insisted that abnormal responses in adults reflect ontogenetic evolution. Moro (1918, 1920) has described a sternal reflex in infants resembling that of Sherrington. After four months of life Moro's reflex becomes inhibited, though persisting much longer in mentally deficient infants. These observations are of great value in understanding the sternal reflex which can be elicited in the presence of cerebral damage. Such lesions abolish the physiological suppression and reveal responses which are found in the early stages of ontogenetic and phylogenetic evolution. Even in physiological states, when subcortical centres are preponderant—that is, during sound sleep—reflexes similar to those described by Sherrington can be obtained by stimulating the skin

of the sternal area with a pin. This phenomenon is much more evident in women than in men. Appropriate stimuli elicit reflexes resembling the embrace reactions, accompanied by a defence component when the stimulus becomes stronger.

I first observed these reactions in 1936 in physiological sleep and in pathological somnolence. The specific sensitivity is strictly limited to the sternal area. Stimulation of other parts of the body is ineffective. Further observations on responses to sternal stimuli showed two different types of reactions, similar to the biphasic Moro reflex. In the first (extensor) phase of Moro's reflex the upper and lower extremities become extended, the arms and fingers abducted, and the head becomes extended. Similar responses occur on stimulation of the sternal area in comatose patients with cerebral lesions. We call them the "decerebrate reactions." In the second (flexor) phase of Moro's reflex the upper limbs become flexed and adducted to the thorax and the lower limbs are flexed. This resembles the first type of sternal reflex often found in heavy stupor or coma resulting from cerebral damage. The decerebrate reactions are less common. Both forms of sternal reflex occur separately.

Significance in Diagnosis

The significance of the sternal area and the sternal reflex in clinical diagnosis was first appreciated by Witold Chodzko. In 1909 he described the sternal reflex: strong percussion of the manubrial area elicited unilateral or bilateral contraction of the biceps. This flexion was accompanied by contraction of other flexors of the upper limbs and sometimes by flexion of the lower limbs. In 169 patients suffering from various psychiatric disorders the phenomenon was present in 28. Chodzko regarded this reflex as a result of pyramidal damage and release of the defence reaction.

Reflexes from the sternal area were also described by Guillain (1925) and Alajouanine. Smirnow (1934) independently described a phenomenon resembling Chodzko's reflex. Astwazaturow (1923, 1929, 1931) emphasizes that sternal responses belong to the "axis reflexes," which can be evoked from the midline of the trunk. Zeldowicz (1937) published his observations on Chodzko's reflex in 192 cases suffering from various central nervous diseases and found it positive in 33%. The two types of sternal reflex are not identical with the responses described above, though the area from which they can be elicited is the same. Responses described by Chodzko and the other authors, except Moro's reflex, result in a single muscle contraction, while our phenomenon consists of compound movement involving upper and lower limbs and the head, and associated with autonomic responses. Our reflex can be produced by repeated pricking at the midline of the manubrial area in cases with heavy stupor or coma resulting from cerebral damage, and never in cases with unaltered consciousness.

The responses to manubrial stimulation have shown that this area is connected with the spinal cord, with all the motor nuclei of the medulla, pons, and midbrain, and with the extrapyramidal nuclei and cerebral cortex. Lesions which interrupt the reflex at any point cause defective responses or abolition of the reflex. Clinical observations on more than 1,000 cases have led to the recognition of two types of sternal responses, depending on the site of the lesion.

Two Types of Sternal Response

The first and more common form of our sternal reflex consists of unilateral or bilateral movements of the upper extremities directed towards the removal of the irritating stimulus. As the stimulus becomes stronger, simultaneous or gradual flexion of one or both lower limbs develops, followed by head movements and pain reactions of the face, which may be symmetrical or unilateral, depending on the state of the cerebrum. Autonomic reactions—that is, mydriasis, acceleration of pulse and respiratory rate, and increase in blood-pressure

Sternal stimulus causes motor reaction of the right limbs = positive sternal reflex. No reaction of the left limbs = negative sternal reflex.

—occur. All these responses must be observed as a whole. Motor reactions differ in their location, vigour, and extent. A unilateral reflex with abolition of motor responses on the opposite side indicates hemiplegia. Defective movements of the upper and lower limbs and face indicate hemiparesis. The hemiplegic or hemiparetic side shows either no responses or defective responses, depending on the extent of the lesion. The value of our sternal reflex became apparent in several patients with severe cerebral damage, where ordinary neurological examination had failed to reveal the site of the lesion. The sternal reflex may assist in determining the side of the lesion in haemorrhages, softenings, etc., of the cerebral hemispheres.

The second type of sternal reflex may be observed in lesions of the brain-stem. Sternal pricking results in decerebrate or similar reactions, with characteristic transient rigidity of the limbs and neck. The rigidity disappears as soon as the stimulus is withdrawn. Usually we see extensor rigidity of the upper limbs. Sometimes the rigidity of the upper limbs becomes flexor in type, with extension of the lower limbs. Sometimes sternal stimulation has resulted in extension of the upper limbs without rigidity. In some cases decerebrate reactions are evident but unilateral. This second form of sternal response has been seen by me and my assistants only in cases with direct or indirect lesions of the midbrain, pons, or medulla, and in cases with ventricular haemorrhage and clots in the fourth ventricle or cisterna magna. Decerebrate reactions have also been observed in conditions resulting in increased intracranial pressure with signs of incipient coning, especially in cases with intracranial tumours. We have never seen decerebrate reactions in lesions of the hemisphere only.

Necropsy Evidence

The diagnostic value of both forms of sternal responses has been confirmed by necropsy in cases of

intracranial tumour, ventricular haemorrhage, meningo-encephalitis, or trauma, accompanied by somnolence, stupor, or coma.

Case 1.—A woman aged 54, transferred from the gynaecological department, complained of severe headache and drowsiness. During lucid intervals neurological examination showed no distinct parietic signs, but marked neck rigidity and tendency for the Babinski sign to be positive on the left side. She could neither stand nor walk. There was bilateral papilloedema. When she was somnolent the sternal response became evident. Sternal stimuli evoked movements of the right limbs. Strong pricking revealed defective movements of the left limbs, more pronounced in the upper left limb. Further investigations revealed a tumour in the right frontal lobe for which a cranial decompression was performed. She died a few days later. At necropsy a metastatic adenocarcinoma was found in the right frontal lobe. In this case the sternal responses facilitated location of the lesion when the usual clinical examination revealed no certain parietic signs.

Case 2.—A 61-year-old woman was treated for chronic endocarditis for one year. On February 14, 1959, she complained of feeling worse and was found comatose a few hours later. On admission she was comatose, with the face turned a little to the right, eyes shut, no active movement, rapid respiration, irregular pulse rate (96 a minute), blood-pressure 115/75; the limbs were rather flaccid, with diminished tendon reflexes. There were no lateralizing signs. Babinski's sign was absent. Strong pricking of the manubrial area elicited motor reaction of the right limbs and a feeble reaction of the left limbs. In these circumstances a left hemiparesis could be assumed as probably a result of cerebral embolism. The same stimuli applied to other areas of the body produced no notable reaction. A few days later, when consciousness was regained, neurological examination revealed a left capsular hemiparesis, and later a left hemiplegia developed, due to embolic damage of the right internal capsule and adjacent basal nuclei reaching the quadrigeminal region.

Case 3.—A man aged 47 was referred from the otological department complaining of a severe right-sided earache over a long period. Otological examination showed otitis media. Signs of meningeal irritation and stupor developed. An intracranial abscess was suspected. Ordinary neurological examination showed no certain signs of a cerebral lesion. After a few days the patient became somnolent and uncooperative. Sternal response showed a brisk defensive reaction of the right limbs. The response of the left limbs was defective. A suspected abscess of the right temporal lobe was confirmed by further investigations and surgical treatment.

Case 4.—A boy aged 9 was admitted to the surgical department with a head injury. He was somnolent and began to vomit. Pricking of the manubrial area showed a characteristic defensive response of the right limbs. The movements of the left limbs were weakened. He was later found to have a subdural haematoma.

As was mentioned above, the second form of the sternal reflex evokes muscle rigidity as is seen in decerebrate conditions.

Case 5.—A man aged 62, admitted to the neurological department, was hypertensive and complaining of severe headache. On admission he was conscious and showed slight signs of meningeal irritation. Blood-pressure 210/110. Neurological examination revealed no paresis. On October 11, 1950, sudden coma developed and painful stimuli applied to the extremities caused no responses. Pricking of the manubrial area caused a tonic extensor reaction of the upper and lower limbs; this ceased as soon as the stimulus was withdrawn. Signs of decerebrate rigidity developed every time the sternum was pricked. The patient died, and at necropsy a haemorrhage arising from the floor of the fourth ventricle was found.

Case 6.—A man aged 35 was admitted in coma to the internal department. He was already being treated in this department for chronic nephritis and hypertension. On admission he showed no voluntary movements of the extremities, his eyes were shut, and reflex iridoplegia was found. Sternal irritation evoked muscle rigidity with some flexion of the upper extremities and extension of the lower limbs, much more pronounced on the left side. Swallowing, slight movements of the lips, acceleration of pulse and respiratory rate, neck rigidity, and a slight rotation of the head to the left were observed. The patient died on the second day after admission, and necropsy revealed a haemorrhage into the left hemisphere, bursting into the ventricle and subarachnoid space of the posterior fossa. Blood clots were also found in the fourth ventricle.

The decerebrate reactions were different in each case, but in every case sternal stimulation evoked the same response at all times. Pricking in other places of the body produced no reaction. Sometimes the manubrial response was partial at the beginning of the disease (only the upper or lower limbs on one side reacted without neck rigidity), becoming more generalized as the disease developed. In other cases slight increase of muscle tone was seen, accompanied by flexion of the fingers. All these signs disappeared when the stimulus was withdrawn.

Case 7.—A physician aged 58 was admitted to the neurological department with a slowly progressive right hemiparesis accompanied by aphasia. He had been treated for years as a case of Buerger's disease, and vasodilator and anti-Parkinsonian drugs improved his condition. Tendon reflexes were increased on the right side and the plantar response on the right was extensor. He also showed some extrapyramidal signs such as bradykinesia and lack of facial mobility. He was a little euphoric and demented. Radiography of the skull showed enlargement of the vascular channels in the left fronto-temporal area. A slight degree of swelling of the optic disk on the left was found. Hypertonic sucrose solution was injected and a lumbar puncture performed. The protein was 66 mg./100 ml., otherwise the cerebrospinal fluid was normal. After puncture the patient became somnolent and the right hemiparesis more marked. Manubrial pricking caused tonic extensor movements of the upper and lower limbs, especially on the left side. Craniotomy revealed an intracranial tumour (meningioma) of the left frontal lobe.

Conclusions

The pathology of the decerebrate reactions is not clearly understood. In several cases necropsy showed that this form of sternal reflex is closely related to indirect or direct damage to the brain-stem below the corpora quadrigemina, the pons, and the medulla. Although many papers have appeared on this subject since Sherrington's publications, decerebrate rigidity in man and animals is still not fully explained. It is uncertain what element causes decerebrate rigidity in man. The symptomatology of decerebrate states is not uniform, and some authors insist that decerebrate phenomena in man and animals have a different pathomechanism. The works of Spatz (1927), Putnam (1933, 1940), Fulton (1943), and Futer (1947) are of special value. Futer discusses his own observations on the subject, particularly concerning decerebrate rigidity in man. It may be assumed that not only lesions of the red nucleus, vestibular nuclei, and cerebellum influence the decerebrate states, but also lesions placed at lower levels of the brain-stem. It is certain that preservation of sensory receptors of the skin is important for the development of decerebrate rigidity. Foerster (1927)

could abolish decerebrate rigidity by interrupting the connexions of the skin receptors. Responses evoked by sternal stimuli cannot be elicited from any other area of the skin, which suggests that sensory receptors in the midline of the sternal area play a special part in the elicitation of decerebrate responses.

Summary

A new sternal reflex, elicitable in states of organic cerebral damage with somnolence or coma, is described.

The special susceptibility of the sternal region, due to ontogenetic and phylogenetic factors, is discussed. Pain stimuli applied to the manubrial area evoke defence reactions (motor and autonomic) which are impaired or absent on the side of the paresis or paralysis. In lesions affecting the brain-stem decerebrate reactions are observed.

Brief illustrative case histories are given.

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POST-OPERATIVE INFECTION IN A CASUALTY DEPARTMENT

BY

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Casualty departments have often been criticized. Clarkson (1956), for example, stated that in his opinion current arrangements in casualty departments throughout the country were the biggest single defect in the Health Service. The recent report of the Nuffield Provincial Hospitals Trust (1960), based on twenty casualty departments serving a population of over five million people, concluded that there was a need for leadership and urgent executive action on the part of the hospital authorities to review, reorganize, and improve the service for casualties.

Many out-patients come to a casualty department for the treatment of wounds or for minor surgical operations. In either instance there is a risk of wound infection which entails discomfort or perhaps danger to the patient and delay in discharge. This subsequent wound sepsis may arise in several ways. It may be due to an extraneous infection introduced pre-operatively in laceration cases, to infection with the patient's own organisms, to cross-infection occurring in the operating theatre, or to post-operative contamination of the wound.

In recent years the investigation of sepsis occurring in hospital has led to modification in ward and operating-theatre practice and design. By contrast the occurrence of sepsis in out-patient departments has not been the subject of such detailed study, although a clearer understanding of the way in which it is caused would be valuable in planning new departments and in modernizing old ones. Several questions need to be answered. For example, there is uncertainty about the danger incurred in treating clean and septic patients in a single operating-theatre.

In this hospital one theatre is used for the surgical treatment of all casualty patients, both clean and septic (other than those attending special departments). We here describe an investigation which relates primarily to 362 clean patients and which has been designed to see if wound infection in the latter could be traced to the coincidental treatment of patients with septic lesions.

Methods

Operating-theatre.—This was a room of 575 sq. ft. (53.5 sq. m.) containing three operating-tables. Instruments were sterilized by boiling. The theatre was ventilated by three small extractor fans. At any one time the nursing staff consisted of a sister and a nurse; the surgical staff was drawn from registrars, house-surgeons, and students. For every patient the operator scrubbed up and wore a gown and a mask: gloves were worn for some clean cases and for all septic cases.

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